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A mobile measurement system for urban immission-monitoring using satellite navigation

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Abstract

A mobile measurement system for immission monitoring has been developed. The detection system is mounted on a vehicle in a roof-box. This enables travels along the road network and collecting of immission data at particular reference locations. During a roundtrip the system receive concentration data for every reference location. These values provide daily profiles of toxic gas and pm10 concentrations, which are plotted into a digital environment map.

1. Introduction

In urban context more than 50% of immissions of toxic gases and pm10-particles with impact on inhabitants are caused by traffic. Different instruments have been developed to achieve air quality as required by European regulations: e.g. congestion charging (London), or environmental zones with access restrictions (Germany). Today it is still difficult to determine emitants of pollution and to quantify the impact of implementing particular measures for pollution reduction. In addition traffic management centers are increasingly involved in developing new traffic control strategies that minimize emissions in general and are tasked with environmental monitoring as far as traffic related immissions are concerned. In order to perform those tasks the environmental measurement systems of today must be updated from a few fixed-point measurements with roadside containers towards a flexible, mobile and real-time system, which delivers road network data (fig 1).

We developed such a measurement systems which enables the following three features:

- Precise re-positioning of sensors with accurate orientation at defined reference positions along road-network
- during measurement ‚on the move' the obtained concentration data is related to precise locations
- in particular the new Galileo non-open services provide the required level of court-proof to activate dynamically measures of traffic control to prevent exceeding of given immission levels.

2. System description

During operation, the mobile system records complete sets of measurement data in a semi-automated way, i.e. the data recording starts as soon as the system is located. The measured data are stored in an online database and at the same time made available for the user. With an authentication, individual users and

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public authorities can access data from other test points.

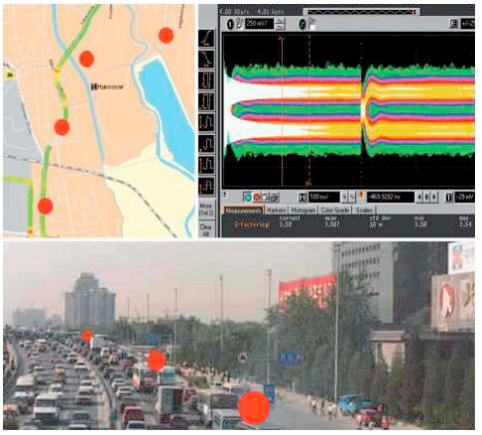

Fig. 1: Scenario: a mobile detection system mounted on a vehicle (roof-box) travels along the road network and collects immission data at particular reference locations. One roundtrip lasts approx. one hour, so we receive one value for every reference location per hour. These values provide daily profiles of toxic gas and pm10 concentrations, which are plotted into a digital environment map.

Both the determination of the location and the measurement data have to be calibrated for accreditation, so that preemptive measures for traffic circulation control can be taken. Apart from the data variation depending on the test point, the location of the test point must hold in court. This is guaranteed by novel localization technologies.

3. Demonstrator

A demonstrator system for the simultaneous measurement of toxic gases and particulate matter (PM), down to PM 10, was developed (Fig. 2). The concentrations of following toxic gases can be determined:

- volatile organic compounds
- ozone
- carbon oxides (CO, CO_2)
- nitric oxides (NO, NO_2)
- ammonia
- methane

The system includes sensors based on different measurement principles, among them IR-optical sensors adapted for methane and ammonia detection [1], commercially available chemical gas sensors and a semiconductor gas sensor suitable for detecting volatile organic compounds and other reactive gases at low concentrations [2]. Furthermore, particulate matter concentration, humidity and temperature are recorded.

The system has a modular setup, i.e. single measurement tasks are distributed in subsystems (Fig. 3). All subsystems are connected via Ethernet. Data evaluation is accomplished using field-programmable gate arrays (FPGA), yielding the gas and PM concentrations. The integration of a GPS receiver allows the localization of the system. A mobile application enables the user to visualize the measured data immediately or to control the measurements (fig. 3).

Fig. 2: (top) Demonstrator system for emission-monitoring. (bottom) The mobile detection system mounted on a vehicle in a roof-box

To date, the system uses a commercial GPS receiver. Starting in autumn 2010, the receiver technology Galileo is planned to be integrated.
Galileo is an independent, pan-European satellite navigation system to be launched in 2012. The Galileo project is a joint collaboration between the European Commission and European Space Agency (ESA) and part of the TEN project (Trans-European Networks). Contrary to GPS, Galileo is not controlled by the military. Due to a strong assignment to the commission to complete the work on the Galileo infrastructure, several research groups work on the development of

mobile applications, in particular sovereign, to be supported by secured, non-public Galileo services.

On July 26th 2007, the USA and the EU announced the collaboration on the improvement of the signals provided by their global satellite navigation network systems (GNSS – Global Navigation Satellite System). These signals are to be used by open services of Galileo and a novel civil system GPS IIIA [3]. This ensures the compatibility and interoperability of both systems. Nevertheless, Galileo will be independent from GPS and differ in various aspects:

- Galileo is not controlled by military.
- Galileo offers five user-oriented services.
- Availability of an integrity signal (i.e. quality of the signal at a specific test point).
- The quality of the signals is guaranteed and thus usable in courts of law.

Especially the use of Galileo data in courts of law is decisive to allow a direct influence on traffic circulation issues based on the measured data.

Fig. 3: Wireless read out of the achieved measuring results. The graphical and numerical visualization of measured data is implemented on a mobile phone.

6. Summary

A mobile measurement system for immission monitoring has been developed. The aim is to establish a dynamic environment index at key locations enabling a direct influence on traffic circulation. On the basis of regularly updated environmental data, the causes and effects of pollutant concentrations can be evaluated. Environmental aspects integrated into the strategic road management allow a direct effect analysis of previously introduced measures and their effectiveness.
Daily concentration gradients of pollutants are evaluated in combination with the prevailing meteorological data to assess the influence of weather conditions on the proportions of different pollutants contributing to the total pollutant emission. This source analysis allows generating reassessed data for the implementation of appropriate protection measures against pollutant emissions.

7. Acknowledgements

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